Department of Energy
Brookhaven Site Office
P.O. Box 5000
Upton, New York 11973

MAR 0 8 2019

Ms. Sharon Hartzell
Federal Facilities Section
U.S. EPA - Region II
290 Broadway - 18th Floor
New York, New York 10007-1866

Mr. Brian Jankauskas
New York State Department of
Environmental Conservation
Division of Environmental Remediation
625 Broadway -12th Floor
Albany, New York 12233

Dear Ms. Hartzell and Mr. Jankauskas:

SUBJECT: BROOKHAVEN NATIONAL LABORATORY (BNL) ADDENDUM TO THE PHASE 3 WORK PLAN FOR CHARACTERIZATION OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) AND RESPONSE TO COMMENTS

Reference: Letter from B. Jankauskas, NYSDEC, to R. Gordon, SC-BHSO, Subject: Brookhaven National Laboratory (Site ID: 152009), dated December 27, 2018

Attached for your review is a copy of the Addendum to the Phase 3 Work Plan for continued characterization of PFAS at BNL. Also attached are responses to the above referenced letter.

The majority of the Phase 3 sampling effort has been completed, and analytical results confirmed the presence of PFAS at BNL's southern boundary and downgradient of the Sewage Treatment Plant. The goal of this addendum is to describe the next steps in the investigation process. This will include the recent sampling of 33 individual groundwater monitoring wells located along the southern boundary and the planned installation of 11 temporary Geoprobe wells.

If you have any questions please contact Jerry Granzen, of my staff, at (631) 344-4089.

Sincerely,

Robert P. Gordon
Site Manager

Attachments:
1. BNL Phase 3 Addendum
2. BNL Response to Comments

cc: J. Swartwout, NYSDEC
T. Papura, NYSDEC
D. O'Hehir, NYSDOH
J. Collins, NYSDOH
S. Karpinski, NYSDOH
A. Juchatz, SCDHS
A. Rapiejko, SCDHS
G. Granzen, SC-BHSO
S. Coleman, BSA
W. Dorsch, BSA
R. Howe, BSA
D. Paquette, BSA
J. Remien, BSA

Comment Number	Section	Comment	Response
Letter from Brian Jankauskas (NYSDEC) to Robert Gordon (DOE) Dated December 27, 2018.			
1	General Comment	Phase 1 investigations conducted at the facility have identified PFAS contamination at suspected source areas and Phase 2 investigations have further assessed these suspected source areas. This step process agrees with Brookhaven National laboratory (BNL) stated position that the preferred method for conducting the PFAS investigation is from the suspected source out. The proposed Phase 3 plan includes the evaluation of PFAS at the on-site treatment systems, sewage treatment plant, and landfills. Collection of samples from the extraction wells will be obtained from the site boundary; however, these samples will likely be diluted by the pumping process which will limit the PFAS investigation. As a result, the proposed plan does not progress the on-site investigation completed during Phase 2. The State recommends including select monitoring wells or temporary wells that are located within the extraction well network to properly evaluate PFAS within the aquifer near the extraction well locations. This information will provide an indication if PFAS has migrated towards the site boundary and can also be used with the extraction well data to better understand how the extraction wells correlate with the aquifer.	BNL has completed most of the sampling effort defined in the Phase 3 work plan. The analytical results received to date have confirmed the presence of PFAS at the southern site boundary and downgradient of the Sewage Treatment Plant (STP). Because of these confirmed detections, BNL has prepared an addendum to the Phase 3 work plan as a next step in the investigation process. As described in the addendum, BNL has recently sampled 33 individual monitoring wells located along the southern boundary and is preparing to install 11 temporary Geoprobe wells along the southern boundary and downgradient of the STP.
2	Table 10	Table 10, sample preservation – Recommend that the samples be maintained at 4 degrees Celsius plus/minus 2 degrees, which is standard.	The sample temperature requirements are defined in EPA Method 537.1 (USEPA, 2018). As stated, samples must not exceed 10°C during the first 48 hours after collection, then be maintained by the analytical laboratory at ≤6°C (but not frozen) until extraction. BNL samples typically arrive at GEL Laboratories at temperatures of 1 to 4 °C.

Comment Number	Section	Comment	Response
3	5	Include submission of a NYSDEC electronic data deliverable, see link blow. https://www.dec.ny.gov/chemical/62440.html	At the end of this characterization effort, BNL will submit all PFAS data to the NYSDEC as an electronic data deliverable (EDD) package in the required format.

BROOKHAVEN NATIONAL LABORATORY

Addendum to the Phase 3 Work Plan Testing for Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater Treatment Systems, Sewage Treatment Plant Effluent, Landfill Monitoring Wells, Southern Boundary Monitoring Wells, and OU V Monitoring Wells

March 5, 2019

Groundwater Protection Group
Environmental Protection Division
Brookhaven National Laboratory
Upton, New York 11973

Brookhaven National Laboratory
Operated by
Brookhaven Science Associates, LLC

Under Contract with the United States Department of Energy
Contract No. DE-SC0012704

1.0 Introduction

The goal of the Phase 3 Work Plan was to test for the presence of PFAS in BNL's onsite groundwater treatment systems, in groundwater downgradient of two closed landfills, in the BNL Sewage Treatment Plant (STP) effluent, and in select Operable Unit V monitoring wells located downgradient of the STP (BNL 2018b). Based upon the analytical results received to date, the scope of the Phase 3 Work Plan is being expanded to include the sampling of 33 existing groundwater monitoring wells located along the southern boundary and the installation of 11 temporary Geoprobe wells along the southern boundary and downgradient of the STP. Furthermore, samples from these wells will also be analyzed for 1,4-dioxane.

2.0 Partial Results of the Phase 3 Sampling Effort

Implementation of the Phase 3 Work Plan started on December 14, 2018 and was mostly completed on February 20, 2019. The only remaining item is the collection of an effluent sample for the recently modified Western South Boundary treatment system. Available analytical results for Phase 3 are summarized below.

2.1 OU III Middle Road and South Boundary Extraction Wells and Treatment System

Analytical results indicate the presence of PFAS in all fourteen sampled extraction wells (**Tables 1 and 2**). Sample locations are shown on **Figure 1**. The types of PFAS compounds detected in the samples are consistent with those detected in the former firehouse area evaluated during the Phase 2 characterization effort. The former firehouse area is located approximately 4,300 feet upgradient of the Middle Road extraction wells and 5,900 feet upgradient of the OU III South Boundary extraction wells. The monitoring results are summarized below:

Middle Road

- Samples from the seven OU III Middle Road extraction wells had combined PFOS/PFOA concentrations ranging from 6.1 ng/L to 22.1 ng/L (**Table 1**).
- The highest PFOS and PFOA concentrations were detected in extraction well RW-2 at 11.2 ng/L and 10.9 ng/L, respectively.

South Boundary

- Samples from the seven OU III South Boundary extraction wells had combined PFOS/PFOA concentrations ranging from 6 ng/L to 31.1 ng/L (**Table 2**).
- The highest PFOS concentration was detected in extraction well EW-5 at 18.9 ng/L, and highest PFOA concentration was detected in well EW-7 at 16.4 ng/L**.**

Combined Effluent

- In the combined OU III South Boundary and Middle Road treatment system effluent sample obtained from the OU III air stripping tower, the PFOS and PFOA concentrations were 4.8 ng/L and 5.8 ng/L, respectively (**Table 2**).

2.2 Western South Boundary Treatment System

Following the installation of four new Western South Boundary extraction wells, the modified treatment system was operated for the first time during the week of February 11, 2019. Samples from the six extraction wells were collected on February 20, 2019 (**Table 3**). Samples of the combined system influent and effluent will be collected once the system is in full-time operation. The available monitoring results are summarized below:

- Low levels of PFOS/PFOA were detected in three of the six extraction wells with combined concentrations ranging from 1.5 ng/L to 8.9 ng/L.
- The highest PFOS and PFOA concentrations were detected in extraction well WSB-1 at 5.7 ng/L and 3.2 ng/L, respectively.

2.3 OU I South Boundary Extraction Wells

Analytical results indicate the presence of PFAS in both extraction wells (**Table 4**). The monitoring results are summarized below:

- Combined PFOS/PFOA concentrations in the two extraction wells were 10.6 ng/L and 10.7 ng/L.
- The highest PFOS concentration was detected in extraction well EW-2 at 7.3 ng/L, and highest PFOA concentration was detected in EW-1 at 5.1 ng/L.

2.4 Chemical Holes Extraction Wells

Analytical results indicated only low levels of PFAS in the two sampled extraction wells (**Table 4**). The third extraction well SR90 EW-1 was out of service for maintenance during the January 11, 2019 sample collection period. The well was repaired, and samples were collected from SR90 EW-1 on February 13, 2019 (analytical results are pending). The available monitoring results are summarized below:

- Combined PFOS/PFOA concentrations for the two extraction wells were 2.1 ng/L and 3.5 ng/L.
- The highest PFOS and PFOA concentrations were detected in extraction well SR90 EW-2 at 1.6J ng/L and 1.9 ng/L, respectively.

2.5 HFBR Extraction Wells

Analytical results indicate the presence of PFAS in all four extraction wells (**Table 4**). The monitoring results are summarized below:

- Combined PFOS/PFOA concentrations ranged from 14.4 ng/L to 20.2 ng/L.
- The highest PFOS and PFOA concentrations were detected in extraction well EW-9 at 13.1 ng/L and 7.1 ng/L, respectively.

2.6 BGRR Sr-90 Extraction Wells and Treatment System

Analytical results indicate the presence of PFAS in all nine extraction wells (**Table 5**). The monitoring results are summarized below:

- Combined PFOS/PFOA concentrations ranged from 6.2 ng/L to 16.4 ng/L.
- The highest PFOS concentration was detected in extraction well SR-6 at 12.3 ng/L, and highest PFOA concentration was detected in well SR-3 at 6.2 ng/L.
- The treatment system effluent sample had PFOS and PFOA concentrations of 3.7 ng/L and 4.2 ng/L, respectively.

2.7 Building 96 and Building 452 Freon-11 System Extraction Wells

PFAS were detected in all five extraction wells (**Table 6**). Monitoring results are summarized below:

- Combined PFOS/PFOA concentrations ranged from 11.2 ng/L to 53.8 ng/L.
- The highest PFOS and PFOA concentrations were detected in extraction well RTW-4 (a recirculation well that is currently in standby mode), with concentrations of 40 ng/L and 18.1 ng/L, respectively.
- Building 452 Freon-11 extraction well EW-18 (currently in standby mode) had PFOS and PFOA concentrations of 20.8 ng/L and 10.9 ng/L, respectively.
- Building 96 extraction well RTW-1 (currently in active operation) had PFOS and PFOA influent concentrations of 17.8 ng/L and 3.8 ng/L, respectively. The treatment system effluent sample had PFOS and PFOA concentrations of 16.2 ng/L and 3.6 ng/L, respectively.

2.8 Sewage Treatment Plant Effluent

PFAS were detected in the STP effluent sample collected on January 7, 2019, with a PFOS concentration of 5.6 ng/L and a PFOA concentration of 40.4 ng/L (**Table 7**). On February 3, 2019, BNL collected an additional STP effluent sample and an influent sample. The analytical data are pending.

2.9 Monitoring Wells

Analytical results for the 12 monitoring wells sampled under the Phase 3 Work Plan are presented in **Tables 8 and 9**. The William Floyd well field outpost wells were sampled first using the existing pumps and discharge tubing that contained Teflon®, then with pumps and discharge lines that were Teflon®-free. The remaining wells were sampled with the existing pumps and discharge lines that contain Teflon® (see discussion in **Attachment 1**). The monitoring results are summarized below:

<u>William Floyd Well Field Outpost Wells (Two Wells)</u>

- William Floyd Well Field outpost wells sampled with pumps and discharge lines containing Teflon®:
  a. PFOS and PFOA were not detected in either sample.
  b. Trace levels of PFBS and PFHxS were detected in the sample from well 109-03.
- William Floyd Well Field outpost wells sampled with Teflon®-free pumps and discharge lines:
  a. No PFAS compounds were detected.

<u>Sewage Treatment Plant/OUV Wells (Five Wells)</u>

- The highest PFOS and PFOA concentrations were detected in STP area monitoring well 039-08 at 261 ng/L and 77.6 ng/L, respectively.

- The second highest PFOS and PFOA concentrations were detected in site boundary well 061-05, with concentrations of 102 ng/L and 20.9 ng/L, respectively.
- Site boundary well 050-01 had PFOS and PFOA concentrations of 29 ng/L and 4.2 ng/L, respectively.
- PFAS were also detected in off-site monitoring well 000-122, with PFOS and PFOA concentrations of 19.5 ng/L and 9.7 ng/L, respectively.

Current Landfill Wells (Three Wells)

- PFAS were detected in all three Current Landfill monitoring wells, with the highest PFOS concentration detected in monitoring well 088-109 at 4.7 ng/L, and highest PFOA concentration detected in well 087-11 at 16 ng/L.

Former Landfill Wells (Two Wells)

- PFOS was not detected in samples from either well. PFOA was detected in both wells at concentrations of 1 ng/L and 3.3 ng/L.

3.0 Phase 3 Addendum Scope of Work

Based upon the Phase 3 monitoring results described above, it is evident that PFAS is present in the groundwater at BNL's southern and southeastern boundary areas. Therefore, the scope of the Phase 3 Work Plan is being expanded to include the sampling of 33 existing groundwater monitoring wells located along the southern boundary and the installation of eleven temporary Geoprobe wells along the southern boundary and downgradient of the STP. Furthermore, to expand upon the initial 1,4-dioxane characterization work that was conducted in 2017 and early 2018 (BNL, 2018a), samples from these wells will also be analyzed for 1,4-dioxane. The aspects of the Phase 3 Addendum are described below.

3.1 Southern Boundary Monitoring Wells

During February 13-22, 2019, thirty-three southern boundary groundwater monitoring wells were sampled for PFAS and 1,4-dioxane (**Table 10**). The locations of the wells are depicted on **Figure 2**, and the well screen depths are depicted in the cross sections presented on **Figures 3 and 4**. The wells are located downgradient of the central developed area of the BNL site, including the current and former firehouse locations which have been identified as significant PFAS source areas. Most of the wells are screened in the deep portion of the Upper Glacial aquifer and at similar depths to the extraction wells that had detectable levels of PFAS.

Based upon the monitoring results described in **Attachment 1**, BNL utilized the existing Teflon®-containing sample pumps and discharge lines for this sampling collection. Following this effort, BNL may install Teflon®-free pumps in select wells to collect groundwater samples for comparison purposes. BNL will continue to utilize the other previously defined best practices to limit potential cross contamination during the collection of samples from the permanent wells and will continue to utilize non-Teflon®-containing equipment for the collection of Geoprobe samples.

3.2 Southern Boundary Geoprobe Wells

Eleven temporary Geoprobe wells will be installed along the BNL southern boundary and downgradient of the STP (**Figure 2**). It is anticipated that these wells will be installed starting in mid-March 2019. Samples will be analyzed for both PFAS and 1,4-dioxane. These temporary wells will help fill in data gaps and help address some of the regulatory agencies' concerns over the possible presence of PFAS and 1,4-dioxane in the shallow groundwater upgradient of private wells that may be located immediately southeast of the BNL site. Sample depths are presented in **Table 11**.

4.0 Sample Collection

4.1 Monitoring Wells

Sampling details are described below:

- Groundwater samples were collected using the existing Teflon®-containing bladder pumps and discharge tubing.
- The wells were sampled in accordance with BNL procedure EM-SOP-302, *Groundwater Sampling – Low Flow Purging and Sampling Using Dedicated Bladder Pumps*.
- Groundwater samples for PFAS analyses were collected using GEL supplied 250 ml polypropylene sample bottles containing Trizma. Groundwater samples for 1,4-dioxane were collected using GEL supplied 250 ml amber glass sample bottles containing sodium bisulfate.
- Except for utilizing existing sample pumps and discharge lines that contain Teflon®, all other precautions described in the *Phase 3 Work Plan* (BNL 2018b) were followed to prevent potential cross contamination of the samples. Sample containers for 1,4-dioxane contain Teflon®-lined caps. Therefore, as a precaution, at each well location, PFAS samples were collected first, followed by 1,4-dioxane. PFAS and 1,4-dioxane sample bottles were kept in separate coolers during sample collection and shipment to GEL.

4.2 Geoprobe Wells

Sampling details are described below:

- Installation and sampling protocols defined in BNL standard operating procedure EM-SOP-311, *Collection of Groundwater Samples Using Geoprobe Wells*, will be used for the collection of groundwater samples. HDPE discharge tubing shall be used.
- Groundwater samples for PFAS will be collected using GEL supplied 250 ml polypropylene sample bottles containing Trizma. Groundwater samples for 1,4-dioxane will be collected using GEL supplied 250 ml amber glass sample bottles containing sodium-bisulfate.
- All precautions listed in the *Phase 3 Work Plan* (BNL 2018c) shall be followed to prevent potential cross contamination of the samples. Sample containers for 1,4-dioxane contain Teflon®-lined caps. Therefore, as a precaution, at each sample interval PFAS samples will be collected first, followed by 1,4-dioxane. PFAS and 1,4-dioxane sample bottles will be kept in separate coolers during sample collection and shipment to GEL.

5.0 Sample Analyses

The water samples will be analyzed by GEL, Charleston, SC, using EPA Method 537 for twenty-one (21) PFAS compounds and by Method 522 for 1,4-dioxane. The samples will be sent to GEL with a requested 30-day turnaround time. A full (Category B) data package will be provided by GEL for both analyses. **Tables 12 and 13** provide summaries of the analytical methods and quality assurance aspects for this effort. As requested by the NYSDEC, at the end of the characterization effort BNL will submit the analytical data set to the State in the appropriate Electronic Data Deliverable format.

6.0 References

BNL 2018a. 2017 Site Environmental Report, Volume 2, Groundwater Status Report. Brookhaven National Laboratory, Upton, New York. June 15, 2018.

BNL 2018b. Phase 3 Work Plan, Testing for Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater Treatment Systems, Sewage Treatment Plant Effluent, Landfill Monitoring Wells, and OU V Monitoring Wells. Brookhaven National Laboratory, Upton, New York. November 30, 2018.

USEPA 2008. Method 522, Determination of 1,4-dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry (GC/MS) with Selected Ion Monitoring (SIM). EPA Document #: EPA/600/R-08/101. September 2008.

USEPA 2018. Method 537.1, Determination of Selected Per- and Polyfluoroalkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). EPA Document #: EPA/600/R-18/352. November 2018.

Table 1. OU III Middle Road Treatment System PFAS Results (ng/L). Samples Collected December 14, 2018.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Sample																						
RW-1	**10.3**	<	<	2.3	2.7	<	6.2	<	9.6	<	<	38.2	10.6	2.6	1.7J	<	<	<	<	<	<	19.9
RW-2	**11.2**	<	<	2.6	2.5	<	6.6	<	**10.9**	<	<	34.1	11.1	2.8	1.6J	<	<	<	<	<	<	22.1
RW-3	3	<	<	1J	1.7J	<	5.5	<	5.8	<	<	26.8	6.1	1.3J	0.7J	<	<	<	<	<	<	8.8
RW-4	7.1	<	<	2.4	10.5	<	8.4	<	8.8	<	<	104	3.2	4.8	1.6J	<	<	<	<	<	<	15.9
RW-5	7.2	<	<	4.3	1.2J	<	6.6	<	5.8	<	<	9.5	9.1	1.7J	3.2	<	1J	<	<	<	<	13
RW-6	4.5	<	<	<	<	<	0.9J	<	1.6J	<	<	4.1	35	<	<	<	<	<	<	<	<	6.1
RW-7	2.2	<	<	<	2.1	<	2.8	<	5.4	<	<	11.6	15.1	2	0.7J	<	<	<	<	<	<	7.6
MR Inf.	5.9	<	<	1.4J	2	<	4.8	<	7	<	<	22.1	11.5	2.2	1.4J	<	<	<	<	<	<	12.9
MR Inf. D	5.4	<	<	1.2J	2.2	<	4.8	<	6.8	<	<	23.6	10.9	1.7	0.9J	<	<	<	<	<	<	12.2
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	--

D: Blind duplicate

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Table 2. OU III South Boundary Treatment System PFAS Results (ng/L). Samples Collected December 14, 2018.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Sample																						
EW-3	3.5	<	<	<	0.8J	<	<	<	2.5	<	<	6.3	7.2	0.9J	<	<	<	<	<	<	<	6
EW-3D	3.5	<	<	<	0.8J	<	<	<	2.9	<	<	5.9	7.2	0.9J	<	<	<	<	<	<	<	6.4
EW-4	**17.6**	<	<	3	3.5	<	8.7	<	**10.9**	<	<	58.2	7.7	2.7	2.7	0.9J	1.1J	<	<	<	<	28.5
EW-5	**18.9**	<	<	1.5J	3.8	<	7.6	<	**12.5**	<	<	69.7	24.6	2.7	1.3J	0.8J	1.1J	<	<	<	<	31.1
EW-6	**11.7**	<	<	2.8	0.9J	<	4.9	<	5.4	1.1J	<	7.2	12.2	1.4J	1.6J	<	4.5	<	<	<	<	17.1
EW-7	**11.8**	<	<	1.7J	3.6	<	5.8	<	**16.4**	<	<	54	6	2.6	2	0.7J	<	<	<	<	<	28.2
EW-8	3.7	<	<	0.8J	<	<	2	<	3.5	<	<	6.9	1.2J	<	0.6J	<	<	<	<	<	<	7.2
EW-17	**10**	<	<	1.3J	1.8	<	4.2	<	5.6	<	<	27.8	8.7	1.6	1.2J	<	0.7J	<	<	<	<	15.6
EW-17 D	9.3	<	<	1.4J	1.9	<	4.3	<	6.4	<	<	27.9	8.6	1.9	1.1J	<	0.7J	<	<	<	<	15.7
SB Inf.	**14.4**	<	<	2.2	2.8	<	6.9	<	**10.3**	<	<	45.3	8.4	2.2	1.6J	0.6J	0.9J	<	<	<	<	24.7
MR/SB Eff.	4.8	<	<	1.4J	2.2	<	4.8	<	5.8	<	<	23.9	10.3	1.8	1.1J	<	<	<	<	<	<	10.6
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	--

D: Blind duplicate

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Inf: Influent

Eff: Effluent

Table 3. OU III Western South Boundary Treatment System PFAS Results (ng/L). Samples Collected February 20, 2019

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Sample																						
WSB-1	5.7	<	<	<	1.7	<	0.9J	<	3.2	<	<	11.7	6.4	1.5J	<	<	<	<	<	<	<	8.9
WSB-2	1.5J	<	<	<	<	<	<	<	<	<	<	2.4	6.4	<	<	<	<	<	<	<	<	1.5
WSB-3	1.1J	<	<	<	1.7J	<	3	<	1.5	<	<	5.2	3.8	1.7	<	<	<	<	<	<	<	2.6
WBS-4	<	<	<	<	0.7J	<	<	<	<	<	<	1.6J	8.7	2.1	<	<	<	<	<	<	<	0
WSB-5	<	<	<	<	<	<	<	<	<	<	<	<	6.2	<	<	<	<	<	<	<	<	0
WSB-6	<	<	<	<	<	<	<	<	<	<	<	<	1.3J	<	<	<	<	<	<	<	<	0
WSB Inf. (a)																						
WSB Eff. (a)																						
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	--

(a): WSB system influent and effluent samples will be collected once the system is in full-time operation.

FRB: Field reagent blank

J: Estimated concentration

<: Not detected. Typical detection limit is 0.6 ng/L

Table 4. OU I South Boundary, Chemical Holes and HFBR Extraction Wells PFAS Results (ng/L). Samples Collected January 11, 2019.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
OUI SB																						
EW-1	5.6	<	<	0.8J	0.6J	<	3.1	<	5.1	<	<	4.5	50.8	0.8J	0.8J	<	<	<	<	<	<	10.7
EW-2	7.3	<	<	0.7J	0.9J	<	2.1	<	3.3	<	<	5.2	26.5	0.9J	0.6J	<	<	<	<	<	<	10.6
Chem Holes																						
SR90 EW-1 (a)																						
SR90 EW-2	1.6J	<	<	<	<	<	0.6J	<	1.9	<	<	0.7J	2.9	<	<	<	<	<	<	<	<	3.5
SR90 EW-3	0.9J	<	<	<	<	<		<	1.2J	<	<	<	1.7J	<	<	<	<	<	<	<	<	2.1
HFBR																						
EW-9	**13.1**	<	<	5	1.3J	<	5.9	<	7.1	<	<	12.3	8.8	1.7	3	<	0.8J	<	<	<	<	20.2
EW-10	9.3	<	<	2.6	1.2J	<	4.2	<	5.1	<	<	11.5	7.5	1.5J	1.8	<	0.6J	<	<	<	<	14.4
EW-11	**11.7**	<	<	2	1.3J	<	3.2	<	5.3	<	<	17.1	4.5	1.4J	1.1J	<	1.9J	<	<	<	<	17
EW-16	9.6	<	<	3.3	0.9J	<	4.2	<	5.3	<	<	12.2	5.7	1.4J	1.8J	<	1.2J	<	<	<	<	14.9
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

(a): Well was out of service on January 11, 2019. Samples were collected February 12, 2019 – data are pending.

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L.

J: Estimated concentration

Table 5. OU III BGRR Sr-90 Treatment System PFAS Results (ng/L). Samples Collected January 17, 2019.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Sample																						
BGRR Influent	6.5	<	<	1.5J	<	<	1.4J	<	3.8	<	<	1.3J	7.5	0.9J	1.2J	<	1.7J	<	<	<	<	10.3
BGRR Effluent	3.7	<	<	1.8J	<	<	1.7J	<	4.2	<	<	1.3J	8.2	1J	1.12J	<	1.5J	<	<	<	<	7.9
SR-1	5.3	<	<	1.7J	<	<	1.9J	<	5.4	<	<	1.6J	11.9	10.2J	2.1	<	0.6J	<	<	<	<	10.7
SR-2	3.6	<	<	1.6J	<	<	1.6J	<	2.6	0.6J	<	1.3J	10.6	0.9J	1.2J	<	0.7J	<	<	<	<	6.2
SR-3	2.4	<	<	1.8J	<	<	1.9	<	6.2	<	<	2.5	2.4	0.8J	0.7J	<	<	<	<	<	<	8.6
SR-4	8.7	<	<	1.5J	<	<	2.1	<	5.5	<	<	2.5	8.5	1.4J	1.1J	<	0.7J	<	<	<	<	14.2
SR-5	7	<	<	1.1J	<	<	1.3J	<	3.3	<	<	1.8J	3.7	0.8J	<	<	<	<	<	<	<	10.3
SR-6	**12.3**	<	<	1.8J	<	<	1.7J	<	4.1	<	<	1.3J	7.4	1.4J	1.3J	<	5.3	<	<	<	<	16.4
SR-7	**10.8**	<	<	1.1J	<	<	0.9J	<	4.3	<	<	2.4	3.1	0.6J	1.2J	<	<	<	<	<	<	15.1
SR-8	8.1	<	<	1.3J	<	<	1.4J	<	3.7	<	<	1.2J	7.1	1.3J	1.4J	<	5.5	<	<	<	<	11.8
SR-9	7	<	<	1.3J	<	<	1.3J	<	3.1	<	<	1.2J	3.9	0.7J	1J	<	0.9J	<	<	<	<	10.1
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Table 6. OU III Building 96 and Freon-11 Treatment Systems PFAS Results (ng/L). Samples Collected December 15, 2018.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Sample																						
RTW-1 Influent	**17.8**	<	<	3	<	<	3.8	<	3.8	<	<	4.1	4.6J	1.2J	1.9	<	0.9J	<	<	<	<	21.6
RTW-1 Effluent	**16.2**	<	<	2.5	<	<	3.6	<	3.6	<	<	3.9	4.1J	1.1J	1.8	<	1.12J	<	<	<	<	21.3
RTW-2 Influent	7.1	<	<	2.8	<	<	4.1	<	4.1	<	<	4.5	4.3J	1.1J	1.7J	<	1J	<	<	<	<	11.2
RTW-2 Effluent	6.4	<	<	3.2	<	<	4.8	<	4.8	0.8J	<	3.7	4.3	1.2J	3	<	1.7J	<	<	<	<	11.9
RTW-3 Influent	9.1	<	<	3.8	<	<	4.9	<	4.9	0.6J	<	5	3	1.2J	1.6J	<	1.2J	<	<	<	<	13.1
RTW-4 Influent	**40**	<	<	11.1	0.8J	<	18.1	<	**18.1**	1.9J	<	8.8	30.3	2.8	5	<	4.2	<	<	<	<	53.8
EW-18 Influent	**20.8**	<	<	7.4	0.9J	<	10.9	<	**10.9**	<	<	11.1	7.3	1.7	5.2	<	2	<	<	<	<	29.5
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	--

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Table 7. Sewage Treatment Plant Effluent PFAS Results (ng/L). Samples Collected January 7, 2019.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
STP Effluent	5.6	<	<	9.6	<	<	6.8	<	**40.4**	<	<	1.4J	7.1	1.1J	2.1	<	3.7	<	<	<	<	46
STP Effluent Re-analysis (RE)	5.5h	<h	<h	11.1h	<h	<h	7.1h	<h	**43.7h**	<h	<h	1.8h	7h	1.5Jh	3.1h	<h	3.4h	<h	<h	<h	<h	49.2
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	--

RE: Sample was re-extracted

h: Preparation or preservation holding time was exceeded

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Table 8. William Floyd Well Field Outpost Well PFAS Results (ng/L). Sampled December 17, 2018 with Teflon®-containing Pumps and Discharge Lines. Sampled January 7, 2019 with Teflon®-free Pumps and Discharge Lines.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)
Wm. Floyd Outpost Wells																					
109-03 (with Teflon)	<	<	<	<	<	<	<	<	<	<	<	1.5J	<	0.7J	<	<	<	<	<	<	<
109-03 (w/o Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
109-04 (with Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
109-04 (w/o Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FRB (12/17/18)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FRB (1/7/19)	<	<	<	<	<	<	<	<	<	<	<	2	<	1.2J	<	<	<	<	<	<	<

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L.

J: Estimated concentration

Table 9. Sewage Treatment Plant, OU V, Current Landfill, and Former Landfill Monitoring Well PFAS Results (ng/L). Sampled with Teflon®-Containing Pumps and Discharge Lines. Samples Collected January 11, 2019.

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
Current Landfill																						
087-11	<	<	<	12.1	0.7J	<	10.3	<	**16**	<	<	9.9	23.9	1.1J	3.4	<	<	<	<	<	<	16
088-109	4.7	<	<	0.9J	1J	<	1.3J	<	7.8	<	<	24.5	6.6	1.3J	1.4J	<	<	<	<	<	<	12.5
088-110	0.6J	<	<	1J	<	<	1.4J	<	2.7	<	<	1.7	4.2	<	<	<	<	<	<	<	<	3.3
Former Landfill																						
097-64	<	<	<	1J	<	<	0.8J	<	1J	<	<	<	2.2	<	<	<	<	<	<	<	<	1
106-30	<	<	<	<	<	<	1J	<	3.3	<	<	1.5J	3.3	<	1J	<	<	<	<	<	<	3.3
STP and OU V																						
039-08	**261**	<	<	23J	780	<	178	<	**77.6**	1J	1J	1,410	<	263	44.3	1.6J	2.2	<	<	<	10.5	338.6
049-06	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
050-01	**29**	<	<	2.9	0.6J	<	2	<	4.2	0.7J	<	3.6	2.5	0.9J	1.6J	5.7	<	<	<	<	<	33.2
061-05	**102**	<	<	5.2	40.2	<	6.9	<	**20.9**	0.7J	<	22.4	7.2	2.8	2.9	2.1	2.3	<	<	<	<	122.9
000-122	**19.5**	<	<	0.6J	0.8J	<	2.6	<	9.7	<	<	4.4	12.3	1.2J	0.9J	<	<	<	<	<	<	29.2
000-122 D	**19.1**	<	<	0.6J	1J	<	2.3	<	8.3	<	<	4.2	9.2	1J	0.6J	<	<	<	<	<	<	27.4
FRB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

D: Blind duplicate

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L

J: Estimated concentration

Table 10. Phase 3 Addendum, Southern Site Boundary Monitoring Wells to be Sampled for PFAS and 1,4-dioxane.

Well ID	Screen Depth (BLS)	Aquifer Segment
114-06	180-190	Deep Glacial
114-07	200-210	Deep Glacial
121-08	180-190	Deep Glacial
121-10	160-170	Deep Glacial
121-11	200-210	Deep Glacial
121-14	190-200	Deep Glacial
121-20	180-200	Deep Glacial
121-23	180-200	Deep Glacial
121-40	281-301	Upper Magothy
121-44	260-280	Upper Magothy
121-47	224-234	Deep Glacial
121-48	223-233	Deep Glacial
121-49	210-220	Deep Glacial
122-04	200-205	Deep Glacial
122-05	269-274	Upper Magothy
122-09	110-120	Mid Glacial
122-10	150-160	Deep Glacial
122-17	200-220	Deep Glacial
122-18	130-150	Mid Glacial
122-19	190-210	Deep Glacial
122-21	180-190	Deep Glacial
122-22	200-210	Deep Glacial
122-31	150-160	Mid Glacial
122-32	200-210	Deep Glacial
122-33	165-195	Deep Glacial
122-41	315-335	Upper Magothy
126-13	150-160	Deep Glacial
126-15	150-160	Deep Glacial
126-18	160-170	Deep Glacial
126-19	190-200	Deep Glacial
127-06	150-160	Deep Glacial
130-02	105-125	Mid Glacial
130-03	160-165	Deep Glacial

BLS: Feet below land surface

Table 11. Phase 3 Addendum, Southern Boundary Geoprobe sample collection intervals for PFAS and 1,4-dioxane.

Well	GP-44	GP-45	GP-46	GP-47	GP-48	GP-49	GP-50	GP-51	GP-52	GP-53	GP-54
Land Surface Elev. (Feet AMSL)	81	81	81	73	73	65	63	45	51	47	43
Water Table Elev. (Feet AMSL)	31	31	31	31	31	32	32	33	33	35	35
Depth to Water (Feet BLS)	50	50	50	42	42	33	31	12	18	12	8
Sample Depth (Feet BLS)	10-foot sample intervals										
	70-74	70-74	70-74	60-64	60-64	50-54	50-54	30-34	30-34	15-19	15-19
	80-84	80-84	80-84	70-74	70-74	60-64	60-64	40-44	40-44	40-44	40-44
	90-94	90-94	90-94	80-84	80-84	70-74	70-74	50-54	50-54	50-54	50-54
	100-104	100-104	100-104	90-94	90-94	80-84	80-84	60-64	60-64	60-64	60-64
	110-114	110-114	110-114	100-104	100-104	90-94	90-94	70-74	70-74	70-74	70-74
	120-124	120-124	120-124	110-114	110-114	100-104	100-104	80-84	80-84	80-84	80-84
	130-134	130-134	130-134	120-124	120-124	110-114	110-114	90-94	90-94	90-94	90-94
	140-144	140-144	140-144	130-134	130-134	120-124	120-124	100-104	100-104	100-104	100-104
	150-154	150-154	150-154	140-144	140-144	130-134	130-134	110-114	110-114	110-114	110-114
	160-164	160-164	160-164	150-154	150-154	140-144	140-144	120-124	120-124	120-124	120-124
				160-164	160-164	150-154	150-154	130-134	130-134	130-134	130-134
						160-164	160-164	140-144	140-144	140-144	140-144
								150-154	150-154	154-154	150-154
								160-164	160-164	160-164	160-164

Table 12. Analytical Methods/Quality Assurance Summary for PFAS.

Samples	Parameters
Matrix type	Groundwater
Number of well samples	SB monitoring wells = 33 SB Geoprobe samples = 132 Total samples = 165
Number of equipment blanks	Equipment blanks = 4
Number of field reagent blanks - supplied by GEL.	One per daily collection event ~20
Analytical parameters	21 PFAS (see BNL 2018b, Table 9)
Analytical method	EPA Method 537 by LC-MS/MS
Number of MS/MSDs	One set per every 20 wells =~3
Number of duplicate samples	One per every 20 samples/intervals =~8
Sample preservation	Trizma Samples maintained to ≤10°C (Note 1)
Sample container volume and type	250 ml polypropylene bottles; two bottles per sample location/interval
Sample holding times	Time to extraction = 14 days Time to analyze = 28 days

Note 1: Sample temperature requirements as defined in EPA Method 537.1 (USEPA, 2018). Samples must not exceed 10°C during the first 48 hours after collection, then be maintained by the analytical laboratory at ≤6°C (but not frozen) until extraction. BNL samples typically arrive at GEL Laboratories at temperatures of 1 to 4 °C.

Table 13. Analytical Methods/Quality Assurance Summary for 1,4-dioxane.

Samples	Parameters
Matrix type	Groundwater
Number of well samples	Monitoring wells = 33 Geoprobe samples = 132 Total samples = 165
Number of field blanks	Field blanks = 4
Number of trip blanks - supplied by GEL.	One per shipment ~12
Analytical parameters	1,4-dioxane; MDL 0.1 µg/L; PQL 0.2 µg/L
Analytical method	EPA Method 522 by GC-MS/SIM
Number of MS/MSDs	One set per every 20 wells =~3
Number of duplicate samples	One per every 20 samples/intervals =~8
Sample preservation	Sodium bisulfate Samples maintained to <10°C (Note 1)
Sample container volume and type	250 ml amber glass bottles, with Teflon septum
Sample holding times	Time to extraction = 28 days Time to analyze = 28 days after extraction

Note 1: Sample temperature requirements as defined in EPA Method 522 (USEPA, 2008). Samples must not exceed 10°C during the first 48 hours after collection, then be maintained by the analytical laboratory at ≤6°C (but not frozen) until extraction.

Former Bubble Chamber and Blockhouse Area

BNL SITE BOUNDARY

BGRR/WCF Sr-90

Building 902 Area Foam Test

Building 924 Area Foam Test

Current Fire House

SR-1 SR-2 SR-3 SR-4 SR-5 SR-6 SR-7 SR-8 SR-9

Major Petroleum Facility 1986 - Training Area

Former Fire House

Building 526

RA V BASIN

CURRENT LANDFILL

Building 96

RTW-1 RTW-2 RTW-3 RTW-4

OU III BASIN

088-109 087-11 088-110

Recreation Center Area

Stormwater Discharge Area

109-04 109-03

EW-16 EW-9 EW-10 EW-11

HFBR

FORMER LANDFILL

097-64 106-30

SR90 EW-1 SR90 EW-2 SR90 EW-3

Chem Holes Sr-90

Middle Road

RW-1 RW-2 RW-3 RW-4 RW-5 RW-6 RW-7

NEW WSB 3 NEW WSB 4 NEW WSB 5 NEW WSB 6

Western South Boundary

WSB-1 WSB-2

EW-1 EW-2 EW-3 EW-4 EW-5 EW-6 EW-7 EW-8 EW-12 EW-17

OU III South Boundary

OU I South Boundary

UVB-6 UVB-7

WILLIAM FLOYD PKWY.

STP EFFLUENT

039-08

SEWAGE TREATMENT PLANT

049-06

PECONIC RIVER

OU V

050-01

061-05

WADING RIVER RD

NORTH STREET

000-122

BNL SITE BOUNDARY

Long Island Expressway

SOUTH STREET

NORTH STREET

WEEKS AVENUE

SCALE 0 1000 2000 FEET

LEGEND

039-08 MONITORING WELL ID AND PROPOSED SAMPLING LOCATION

REMEDIATION SYSTEMS

EW-5 BNL REMEDIATION WELL ID AND PROPOSED SAMPLING LOCATION

000 BNL GRID NUMBER

P:\2016\BNLab\16-02 Environmental Protection Division\Task 01 General\2018\08 PFCs Characterization\Figures\Phase 3\Fig_1 Phase 3 PFAS 112018.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

PHASE 3 PFAS SAMPLE LOCATIONS

2018 PFAS CHARACTERIZATION

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	11/20/18	–
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	–	–

FIGURE NO.: 1

LEGEND

- 07 — MONITORING WELL
- GP-44 — PROPOSED GEOPROBE WELL
- 30 — 2017 POTENTIOMETRIC SURFACE CONTOUR ELEVATION, IN FEET ABOVE MEAN SEA LEVEL (DASHED WHERE INFERRED)
- GROUNDWATER FLOW DIRECTION
- G G' — HYDROGEOLOGIC CROSS SECTION
- 32 — BNL GRID NUMBER
- EW-12 — BNL REMEDIATION WELL

GP-54 GP-53 GP-52 GP-51 GP-50 GP-49 GP-47 GP-46 GP-45 GP-44 GP-48

CROSS SECTION G - G'

CROSS SECTION H - H'

HO HP HS HWM

RAV BASIN

CHHI BASIN

SCWA WILLIAM FLOYD PKY WELL FIELD

SCWA COUNTRY CLUB DR WELL FIELD

BNL SITE BOUNDARY

WILLIAM FLOYD PARKWAY

Long Island Expressway

SOUTH STREET

NORTH STREET

CARLETON DRIVE

SLEEPY HOLLOW DRIVE

WEEKS AVENUE

MORICHES MIDDLE ISLAND ROAD

SCALE 0 1000 2000 FEET

P:\2016\BNLab\16-02 Environmental Protection Division\Task 14 PFC GAC Evaluation\PFCs Characterization\Figures\Phase 3\2019-02-20\Fig_1 PFAS MW GP South Boundary 022019.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

PROPOSED MONITORING WELL SAMPLING AND GEOPROBE LOCATIONS – PFAS CHARACTERIZATION ALONG BNL SITE BOUNDARY

2019 PFAS PHASE 3 ADDENDUM

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	02/20/19	–
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	–	–
FIGURE NO.: 2			

LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

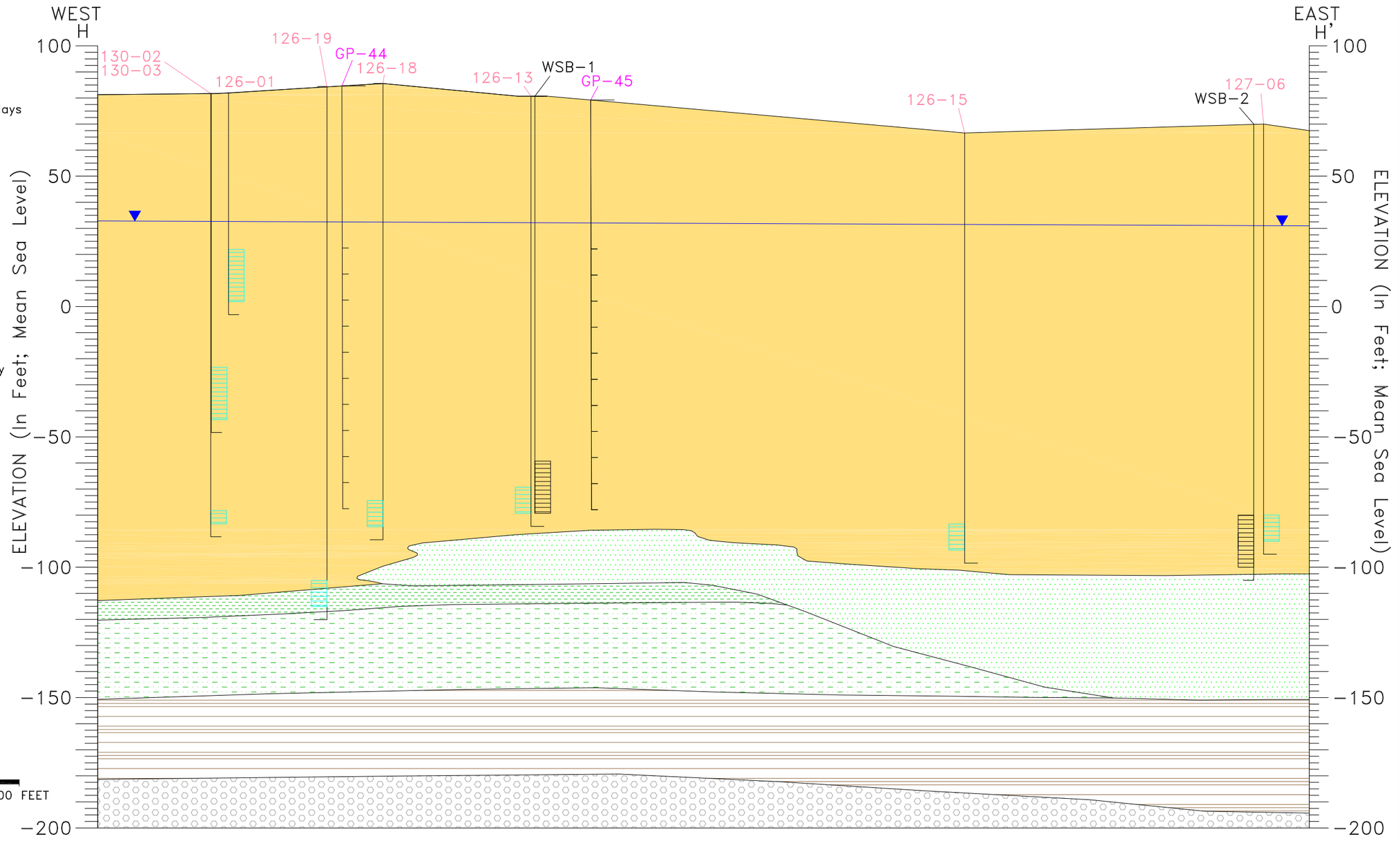
126–01 BNL Well ID

- Monitoring Well Screen
- Extraction Well Screen

Water Table As Of Nov. 27 – Dec. 1, 2017

HORIZONTAL SCALE

0 500 FEET



NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

P:\2016\BNLab\16-02 Environmental Protection Division\Task 14 PFC GAC Evaluation\PFCs Characterization\Figures\Phase 3\2019-02-20\Fig_2 H-H 02-20-19.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

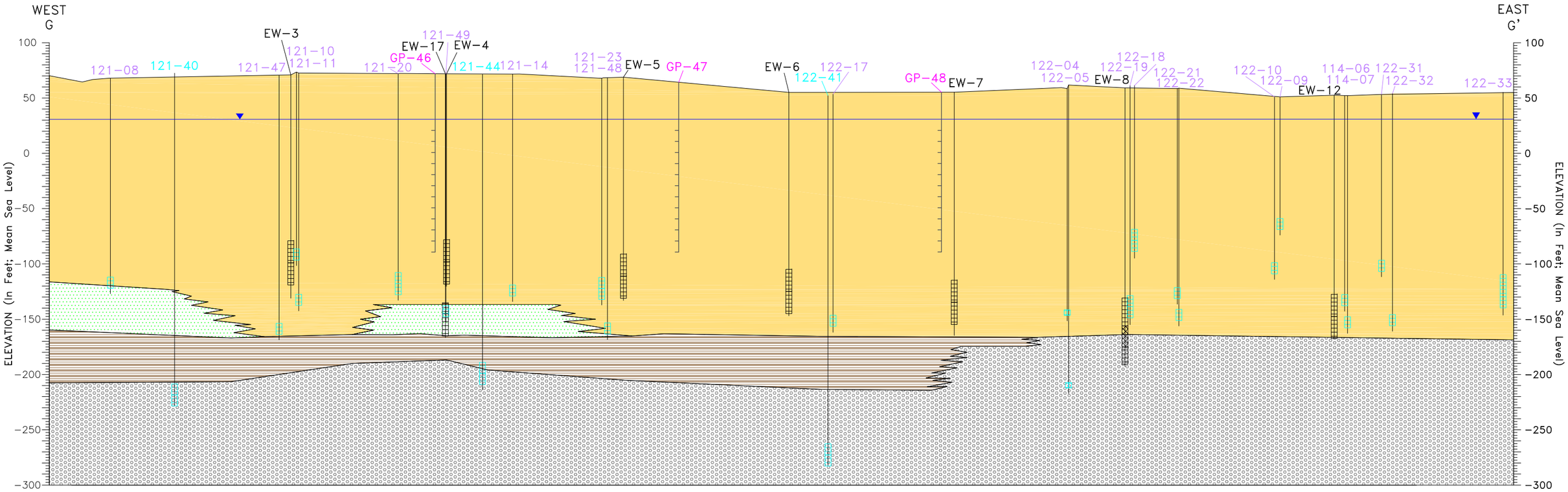
TITLE:

OU III WESTERN SOUTH BOUNDARY HYDROGEOLOGIC CROSS SECTION (H–H')

2019 PFAS PHASE 3 ADDENDUM

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	20:1	02/20/19	–
CHKD:	APPD:	REV.:	NOTES:
JEB	WRD	–	–

FIGURE NO.: 3



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undiff)
- MO Magothy – OTHER

121-07 BNL Well ID

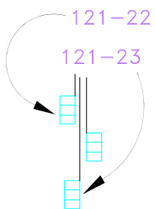
Monitoring Well Screen

Extraction Well Screen

HORIZONTAL SCALE

0 100 200 FEET

Monitoring Well IDs are stacked in order of the depth of the well from shallow to deep



Water Table As Of Nov. 27 – Dec. 1, 2017

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

P:\2016\BNLab\16-02 Environmental Protection Division\Task 14 PFC GAC Evaluation\PFCs Characterization\Figures\Phase 3\2019-02-20\Fig_4 G-G 02-20-19.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III SOUTH BOUNDARY AREA HYDROGEOLOGIC CROSS SECTION (G–G')

2019 PFAS PHASE 3 ADDENDUM

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	2:1	02/20/19	–
CHKD:	APPD:	REV.:	NOTES:
DEP	WRD	–	–

FIGURE NO.: 4

Attachment 1
Assessment of the Potential Cross Contamination of Water Samples by Teflon®

1.0 Teflon® in Equipment Used for the Collection of Water Samples

Since the early 1990's, dedicated bladder pumps have been installed in all BNL monitoring wells that are sampled on a routine basis. The bladder pumps may contain internal components made from polytetrafluoroethylene (PTFE) also referred to as the trade name Teflon®. Furthermore, the pump discharge lines are constructed of Teflon®-lined polyethylene (**Figure A1-1**). Teflon material is also present in ball valves and pipe sealant that are commonly used in BNL's groundwater treatment system piping, including the sample ports (**Figures A1-2 and A1-3**). For the Phase 3 sampling effort, Teflon® or Tygon® flexible discharge tubing attached to the treatment system sample ports was replaced with silicone tubing.

Teflon® has been the preferred material for volatile organic compound (VOC) sampling for many years because, compared to other materials, it does not interact with or adsorb these chemicals. Although published studies on possible sample cross contamination from Teflon® are limited, the current generally accepted practice for PFAS sampling is not to use products made of Teflon® primarily because PFOA was used during its manufacture and residual amounts of this compound may be present in the finished product. In the US, the manufacture and use of PFOA were phased out by late 2015.

If BNL's existing dedicated bladder pumps and discharge tubing were to be replaced, the equipment and labor cost would be on the order of $1,000 per well. Assuming 100 to 150 of BNL's existing monitoring wells could be utilized for long-term PFAS sampling, the cost to switch to Teflon®-free pumps and tubing would be on the order of $100,000 to $150,000. Changing of remediation system piping to eliminate all Teflon® would result in additional costs. Furthermore, the technical issues associated with utilizing the most appropriate pump and discharge tubing materials for wells that are sampled for both PFAS and VOCs would have to be resolved.

2.0 Groundwater Samples Collected with Sample Pumps and Discharge Tubing Containing Teflon®

From December 17, 2018 through January 11, 2019, BNL sampled the 12 permanent wells identified in the Phase 3 Work Plan (BNL 2018). Four additional wells located in areas believed not to have been impacted by past use of firefighting foam were also sampled to evaluate possible cross contamination of groundwater samples when using Teflon®-containing sample pumps and tubing (**Table A1-1**).

William Floyd Well Field Outpost Wells: On December 17, 2018 personnel from BNL and the Suffolk County Department of Health Services (SCDHS) collected groundwater samples from the William Floyd well field outpost wells 109-03 and 109-04 using the existing Teflon®-containing bladder pumps and discharge lines. The samples collected by the SCDHS were analyzed by the Suffolk County Water Authority (SCWA) analytical lab in Hauppauge, NY for six PFAS

compounds, whereas the samples collected by BNL were submitted to General Engineering Laboratories (GEL) and tested for 21 PFAS compounds. Analytical results for the samples analyzed by GEL indicate no detections of PFAS compounds in the sample collected from well 109-04. The typical detection limit for the analyses performed by GEL is 0.6 ng/L. The sample from well 109-03 had low level detections of two PFAS compounds, PFBS at a concentration of 0.7J ng/L and PFHxS at a concentration of 1.5J ng/L (**Table A1-2**). The primary PFAS contaminants of concern, PFOS and PFOA, were not detected. The SCDHS verbally reported that the December 17, 2018 samples submitted to SCWA were non-detect for the six PFAS compounds. However, the detection limits typically achieved by the SCWA lab for PFOS and PFOA are 40 ng/L and 20 ng/L, respectively.[1] The pumps were replaced with Teflon®-free pumps and tubing. On January 7, 2019, a second set of groundwater samples were collected using the new pumps. No PFAS were detected in these samples. The Field Reagent Blank (FRB) had reported concentrations of PFBS at 1.2J ng/L and PFHxS at 2 ng/L. The SCDHS has not yet reported the results for the second set of analyses.

Background Wells: BNL collected additional groundwater samples from four monitoring wells for PFAS testing using existing Teflon®-containing pumps and discharge lines (**Table A1-3**). These wells are located upgradient of known BNL PFAS source areas. Two of the wells are used to monitor the Relativistic Heavy Ion Collider (RHIC) facility and two wells are located upgradient of the Sewage Treatment Plant (STP). In samples from the four wells, PFOS was only detected in upgradient STP area well 037-03 at 0.8J ng/L. PFOA was detected in both RHIC area wells (025-08 and 044-13) at concentrations of 1.2 ng/L and 2 ng/L. Elevated concentrations of PFBA were detected in both RHIC area wells at concentrations of 53.7 ng/L and 316 ng/L. It is unclear whether the PFBA is related to the sample pumps or discharge lines, or whether it is indicative of an undocumented firefighting foam release site, perhaps located along William Floyd Parkway which is located approximately 1,400 feet upgradient of the wells.

OU V and Landfill Area Monitoring Wells: Three of the Phase 3 monitoring wells which were sampled using Teflon®-containing sample pumps and discharge lines had non-detectable to low levels of PFAS. No PFAS were detected in OU V well 049-06. In Former Landfill area wells 097-64 and 106-30, PFOS was not detected in either sample, whereas PFOA was detected at concentrations of 1.0J ng/L and 3 ng/L (**Table A1-3**). Disposal activities at the Former Landfill ended in 1966, and there are no documented releases of firefighting foam in the area.

3.0 Groundwater Extraction Well Sample Ports with Valves and Piping Connections Containing Teflon

As noted above, Teflon® material is present in the ball valves and pipe sealant that are commonly used in BNL's groundwater treatment system piping, including the sample ports. Prior to collecting samples, sample port flexible tubing made of Teflon® or Tygon® was replaced with silicone tubing. Of the treatment systems that were sampled, samples collected from the Chemical Holes and Western South Boundary extraction wells were found to have only low levels of PFAS. In the Chemical Holes extraction wells for which analytical data are available, PFOS was detected at concentrations of 0.9J ng/L and 1.6J ng/L, and PFOA detected at concentrations of 1.2J ng/L and 1.9 ng/L (**Table A1-4**). Disposal activities at the Chemical Holes area occurred from the 1950's until 1981. There is no documented disposal or use of firefighting foam in the Chemical Holes area. In the samples collected from the Western South Boundary extraction wells, PFOS was not detected in wells WSB-4, WSB-5 and WSB-6, and PFOA was not detected in the samples from WSB-2, WSB-4, WSB-5 and WSB-6 (**Table A1-4**). The Western South Boundary area is located

[1] These method Detection Limits were defined under UCMR 3.

downgradient of the Current Firehouse, and it is likely that the low levels of PFOS and PFOA detected in the samples from WSB-1 and WSB-3 originates from this defined source area.

4.0 Available Studies on Cross Contamination

Based upon a web search, two references were found on the potential for Teflon® to cross contaminate environmental samples. QED Environmental Systems (QED), a national manufacturer of groundwater sampling equipment, performed cross contamination tests where a bladder pump and various tubing materials (including Teflon®-lined PE) were soaked in water for 48 to 72 hours (QED 2018). QED reported that no PFAS compounds were detected in any of the water samples tested using EPA Method 537, with an MDL <1 ng/L. Furthermore, as reported in a PFAS sampling guide published on line by LimnoTech (2018), very low levels of only PFHxS and PFBS were reportedly detected in multiple equipment blanks collected from Teflon® liners that are used for soil sampling. Although these results indicate that some PFAS compounds might transfer from Teflon® sampling equipment, the primary contaminants of concern PFOS and PFOA were not detected.

5.0 Summary

In the seven monitoring wells used for this evaluation, PFOS was detected at a maximum concentration of 0.8J ng/L and PFOA was detected at a maximum concentration of 3.3 ng/L (**Table A1-5**). Low levels of PFOS and PFOA were observed in five of the eight extraction well samples (**Table A1-6**). Although it is possible that some of the PFAS compounds detected in these samples originated from the sampling equipment (e.g., PFBA), the PFOS and PFOA concentrations are well below the current 70 ng/L EPA Health Advisory Level for combined levels of PFOS/PFOA and below the recently proposed NYS MCLs of 10 ng/L for both PFOS and PFOA.

For preliminary characterization and decision-making purposes, BNL will continue to utilize the existing Teflon®-containing sampling equipment, including for the permanent well sampling events defined in this Addendum. Following this round of sample collection, BNL may install Teflon®-free pumps in select wells to collect samples for comparison purposes. BNL will continue to utilize previously defined best practices to limit potential cross contamination during the collection of samples from the permanent wells and will continue to utilize Teflon®-free and HDPE equipment for the collection of Geoprobe samples.

For long-term monitoring, BNL will continue to evaluate available research on best sampling practices for wells that are utilized for monitoring both PFAS and VOCs. Furthermore, BNL will evaluate whether valving and piping used to collect treatment system samples can be replaced with suitable Teflon®-free materials. It is anticipated that Teflon®-free sample pumps and discharge tubing would be installed in any new wells used to monitor PFAS source areas.

6.0 References

BNL 2018. Phase 3 Work Plan, Testing for Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater Treatment Systems, Sewage Treatment Plant Effluent, Landfill Monitoring Wells, and OU V Monitoring Wells. Brookhaven National Laboratory, Upton, New York. November 30, 2018.

LimnoTech 2018. Sampling for PFAS Requires Caution. July 10, 2018. (https://www.limno.com/sampling-for-pfas-requires -caution/)

QED Environmental Systems 2018. Testing of QED Sample Pro® 1.75" Portable Bladder Pump for Perfluorinated Compounds. (https://www.qedenv.com/Products/Groundwater_Sampling/Testing_of_QED_Sample_Pro_1_75_Portable_Bladder_Pump_for_Perfluorinated_Compounds).

Figure A1-1. Teflon®-lined Polyethylene Discharge Tubing.

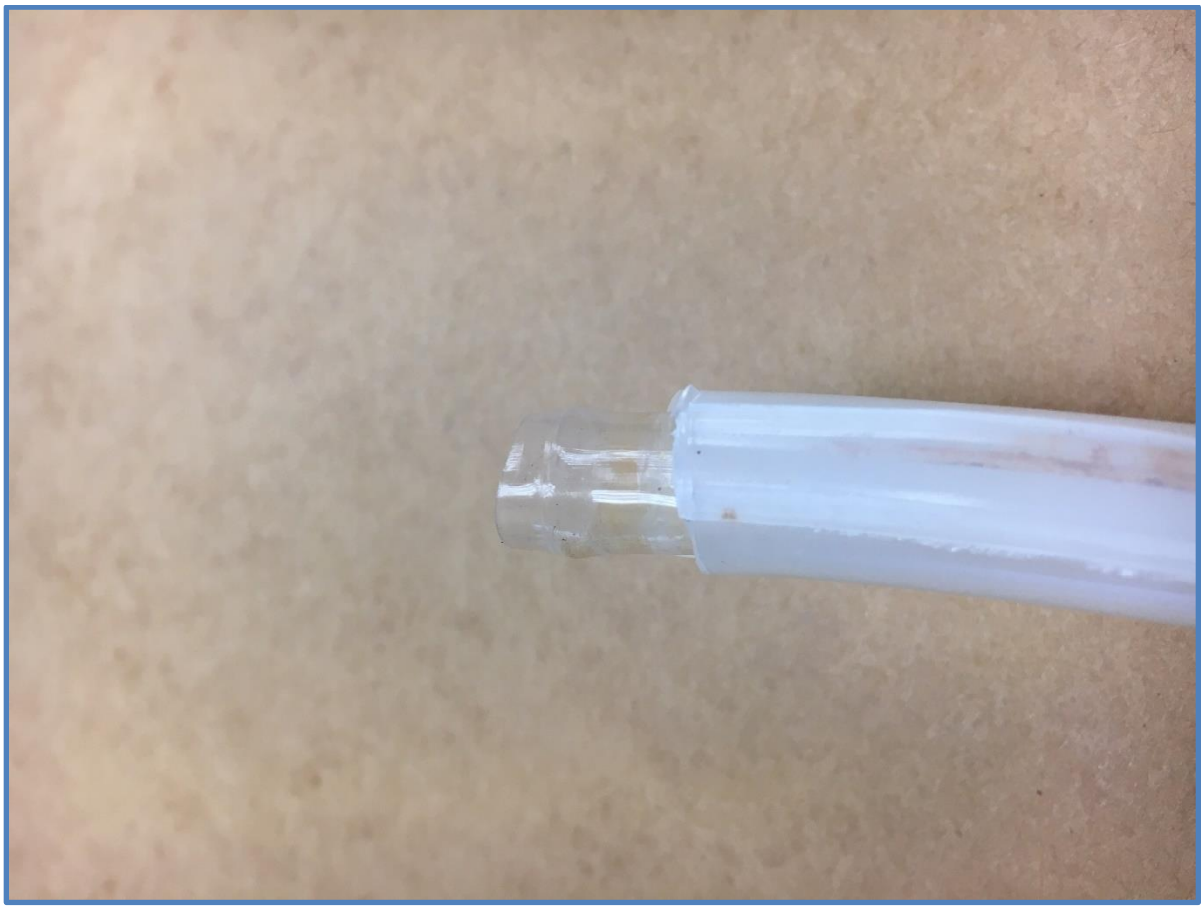


Figure A1-2. OU III South Boundary extraction well sample port with ball valve with a Teflon® seat and pipe connections sealed with Teflon® Ttape.

Figure A1-3. OU III South Boundary extraction well sample ports with ball valves with Teflon® seat and pipe connections sealed with Teflon® tape. Flexible discharge lines are made of silicone.

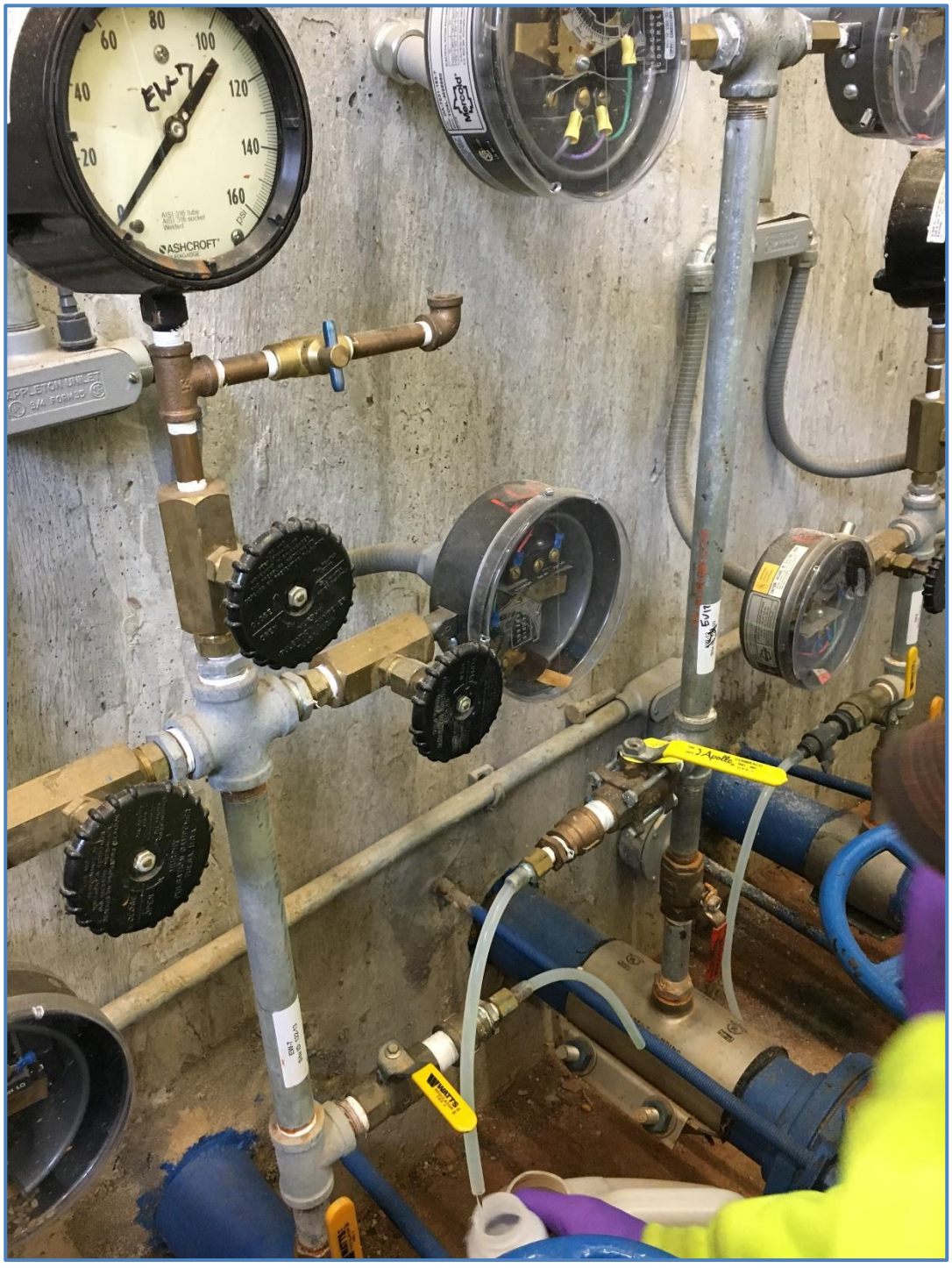


Table A1-1. Monitoring Wells Sampled for PFAS using Teflon-containing Sample Pumps and Discharge Lines.

Well ID	Screen Depth (BLS)	Monitoring Area
Scheduled Phase 3 Wells		
109-03	120’-140’	William Floyd Well Field Outpost
109-04	205’-220’	William Floyd Well Field Outpost
049-06	175’-185’	OU V Downgradient of the STP
097-64	29’-44’	Downgradient of Former Landfill
106-30	29’-44’	Downgradient of Former Landfill
Additional “Background” Wells		
025-08	5’-20’	RHIC
044-13	31’-46’	RHIC
037-02	31’-41’	Upgradient of the STP
037-03	90’-100’	Upgradient of the STP

BLS: Feet below land surface

Table A.1-2
Evaluation of Groundwater Samples Collected from Monitoring Wells with Pumps and Discharge Tubing Containing Teflon®
William Floyd Well Field Outpost Wells
PFAS Concentrations in Nano Grams per Liter (ng/L)
Sampled December 17, 2018 and January 7, 2019

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)
Wm. Floyd Outpost Wells																					
109-03 (with Teflon)	<	<	<	<	<	<	<	<	<	<	<	1.5J	<	0.7J	<	<	<	<	<	<	<
109-03 (w/o Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
109-04 (with Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
109-04 (w/o Teflon)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FRB (12/17/18)	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FRB (1/7/19)	<	<	<	<	<	<	<	<	<	<	<	2	<	1.2J	<	<	<	<	<	<	<

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L.

J: Estimated concentration

Table A.1-3
Evaluation of Groundwater Samples Collected from Monitoring Wells with Pumps and Discharge Tubing Containing Teflon®
RHIC, Former Landfill and STP Areas
PFAS Concentrations in Nano Grams per Liter (ng/L)
Samples Collected January 10-11, 2019

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)
RHIC Area																					
025-08	<	<	<	<	<	<	<	<	2	<	<	<	53.7	<	<	<	<	<	<	<	<
044-13	<	0.9J	<	1.9	<	<	1.3J	<	1.2	<	<	0.7J	316	0.9J	0.7J	<	0.7J	<	<	<	<
STP Upgradient																					
037-02	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
037-02 D	<	<	<	1.4J	<	<	<	<	<	<	<	<	1.1J	<	<	<	<	<	<	<	<
037-03	0.8J	1.7J	<	<	<	<	<	<	<	0.7J	<	<	<	<	<	<	<	0.9J	<	1.2J	<
STP Downgradient																					
049-06	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Former Landfill																					
097-64	<	<	<	1J	<	<	0.8J	<	1J	<	<	<	2.2	<	<	<	<	<	<	<	<
106-30	<	<	<	<	<	<	1J	<	3.3	<	<	1.5J	3.3	<	1J	<	<	<	<	<	<

D: Blind duplicate

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L.

J: Estimated concentration

Table A.1-4

Evaluation of Groundwater Samples Collected from Extraction Wells with Sample Ports that Contain Teflon® Materials

Chem Holes and Western South Boundary Extraction Wells Results

PFAS Concentrations in Nano Grams per Liter (ng/L)

Samples Collected January 11 and 20, 2019

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)
Chemical Holes																					
SR90 EW-1 (a)																					
SR90 EW-2	1.6J	<	<	<	<	<	0.6J	<	1.9	<	<	0.7J	2.9	<	<	<	<	<	<	<	<
SR90 EW-3	0.9J	<	<	<	<	<	<	<	1.2J	<	<	<	1.7J	<	<	<	<	<	<	<	<
Western South Boundary																					
WSB-1	5.7	<	<	<	1.7	<	0.9J	<	3.2	<	<	11.7	6.4	1.5J	<	<	<	<	<	<	<
WSB-2	1.5J	<	<	<	<	<	<	<	<	<	<	2.4	6.4	<	<	<	<	<	<	<	<
WSB-3	1.1J	<	<	<	1.7J	<	3	<	1.5	<	<	5.2	3.8	1.7	<	<	<	<	<	<	<
WBS-4	<	<	<	<	0.7J	<	<	<	<	<	<	1.6J	8.7	2.1	<	<	<	<	<	<	<
WSB-5	<	<	<	<	<	<	<	<	<	<	<	<	6.2	<	<	<	<	<	<	<	<
WSB-6	<	<	<	<	<	<	<	<	<	<	<	<	1.3J	<	<	<	<	<	<	<	<

(a): Well was out of service on January 11, 2019. Samples were collected February 12, 2019 – data are pending.

FRB: Field reagent blank

<: Not detected. Typical detection limit is 0.6 ng/L.

J: Estimated concentration

Table A1-5. PFAS Compounds Detected in Monitoring Well Samples Collected Using Teflon®-Containing Pumps and Discharge Lines.

PFAS Compound	Method Detection Limit (ng/L)	Range of Concentrations (ng/L)	Number of Detections in 9 Monitoring Well Samples
PFOS	0.6	ND - 0.8 J	1
PFOA	0.6	ND - 3.3	4
PFHxS	0.6	ND - 1.5 J	3
PFHxA	0.6	ND - 1.3	3
PFBA	0.6	ND - 316	5
PFBS	0.6	ND - 0.9 J	2
PFHpA	0.6	ND - 1 J	2
PFNA	0.6	ND - 0.7 J	1
PFPeA	0.6	ND - 1.9	3
PFUdA	0.6	ND - 1.7 J	2
PFTrDA	0.6	ND- 1.2 J	1
PFTeDA	0.6	ND - 0.9 J	1
PFDA	0.6	ND - 0.7 J	1

J: Estimated concentration
ND: Not detected

Table A1-6. PFAS Compounds Detected in Chemical Holes and Western South Boundary Extraction Well Samples Collected from Sample Ports that have Ball Valves and Pipe Sealing Tape Made with Teflon®.

PFAS Compound	Method Detection Limit (ng/L)	Range of Concentrations (ng/L)	Number of Detections in 8 Extraction Well Samples
PFOS	0.6	ND - 5.7 (a)	5
PFOA	0.6	ND - 3.2 (a)	4
PFHxS	0.6	ND - 11.7 (a)	5
PFHxA	0.6	ND - 3	3
PFBA	0.6	1.3 J - 8.7	8
PFBS	0.6	ND - 2.1	3
PFPeS	0.6	ND - 1.7	3

a: Highest concentration of this compound was detected in extraction well WSB-1.
J: Estimated concentration
ND: Not detected